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Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

16. Abstract

This report documents the investigation of an impact to an SKT guardrail end terminal by the front plane, right aspect of a 2006 Kia Sedona. The investigation was conducted on behalf of the Federal Highway Administration. The Kia was occupied by a belted 53-year-old female driver, a belted 46-year-old female front-right occupant, and two 3-year-old male child occupants seated in forward-facing child restraint systems in the outboard positions of the second row. The driver reported that, while traveling south in the right lane of a divided highway at night, a tractor-trailer encroached into her lane of travel. She steered the Kia right, braked into a gore area, and struck the SKT end terminal. Impact forces displaced the SKT end terminal along the guardrail and extruded a portion of the W-beam. The Kia's front seat belt pretensioners actuated, and its frontal air bags deployed. The driver and both child occupants were uninjured. The front passenger was transported by ambulance to a local hospital, where she was treated and released within hours of the crash.

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Background

This report documents the investigation of an impact to an SKT guardrail end terminal by the front plane, right aspect of a 2006 Kia Sedona (Figure 1). The investigation was conducted on behalf of the Federal Highway Administration (FHWA). The Kia was occupied by a belted 53-year-old female driver, a belted 46-year-old female front-right occupant, and two 3-year-old male children seated in forward-facing child restraint systems (CRS) in the outboard positions of the second row. The driver reported that, while traveling south in the right lane of a divided highway at night, a tractor-trailer encroached into her lane of travel. She steered the Kia right and braked into a gore area, continued south, and struck the SKT end terminal. Impact forces displaced the SKT end terminal along the guardrail and extruded a portion of the W-beam. The Kia's front seat belt pretensioners actuated, and its frontal air bags deployed. The driver and both child occupants were uninjured. The front passenger was transported by ambulance to a local hospital, where she was treated and released within hours of the crash.

Figure 1. Front right oblique view of the guardrail damage to the Kia Sedona

This crash was identified by the Pennsylvania Turnpike Commission (PTC), which notified the Federal Highway Administration (FHWA). FHWA determined that the crash type and guardrail end terminal met the criteria for further research and subsequently forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration on the day of the crash. The CID assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research and Analysis, Inc., the same day. The SCI team initiated contact with the PTC, and an on-site investigation was conducted within two days of the November crash. The on-site investigation documented the guardrail system and the damage it sustained during the crash. The physical environment of the roadway was documented

using a total station tool and digital photographs. An inspection of the Kia included the documentation of the exterior damage, interior damage, and an assessment of the manual and supplemental restraint systems. The Kia was equipped with an Event Data Recorder (EDR) that was not supported by any tools available to the investigator.

Summary

Crash Site

This guardrail crash occurred at night on a divided interstate highway. At the time of the crash, conditions reported by the National Weather Service included an ambient temperature of 7.7 ºC (46 ºF) with cloudy skies and 100-percent humidity. The winds were out of the north-northeast at 8 km/h (5 mph). Official records documenting the crash indicated that the road surface and environmental conditions were wet. The divided highway was oriented north/south (Figure 2) and consisted of two travel lanes in each direction, physically divided by a concrete jersey-style barrier. The southbound travel lanes each measured 3.5 m (11.5 ft) wide and were straight and level with a recently resurfaced bituminous asphalt surface. Lane delineation consisted of a broken white centerline with a solid yellow east edge line and a solid white west edge line. A narrow 0.7 m (2.3 ft) wide paved shoulder was present between the east edge line and the center barrier. In the vicinity of the crash, the 3.6 m (11.8 ft) wide west shoulder transitioned to an asphalt-surfaced triangular gore area that separated the southbound lanes from an exit ramp. The ramp curved to the right with respect to southbound traffic flow, resulting in an increasing width of the gore area. The surface of the ramp transitioned from new asphalt to a new concrete surface at the south end of the gore area. Loose stone extended beyond the gore and between the shoulders of the southbound lanes and the off-ramp.

Figure 2. Southbound trajectory view of the crash site

A W-beam guardrail system was constructed along the east edge of the off-ramp. The system consisted of an SKT end terminal and protected southbound traffic from entering the swale area between the southbound highway lanes and the off-ramp. The posted speed limit was 113 km/h (70 mph). Although a temporary work zone was established at the time of the SCI scene inspection, there was no work zone present at the time of the crash.

Pre-Crash

The driver of the Kia was traveling south in the right lane at a driver-estimated speed of 113 km/h (70 mph). She stated that a tractor-trailer was traveling in the left lane and passing her vehicle when it suddenly initiated a lane change maneuver to its right and encroached into her

lane of travel. The driver of the Kia steered right into the painted gore area (Figure 3) and applied the brakes to avoid the encroaching combination unit. Tracking tire marks consistent with the Kia's trajectory and braking actions were observed on the asphalt-surface of the gore. The left front tire mark was 26.4 m (86.6 ft) long and the right was 23.1 m (75.8 ft) long. The tire marks arced left counterclockwise as the driver applied a left counter-steer in an attempt to regain directional control.

The tire marks faded as the driver probably released brake pedal pressure. The Kia continued south through the gore area for a distance of 39.0 m (128.0 ft) before it transitioned onto the loose stone and new concrete surfaces (Figure 4). The left-side tires entered the stone surface between the paved shoulders of the highway and the exit ramp, while the right-side tires traveled on the new concrete surface of the ramp. The Kia continued for an additional 31.0 m (101.7 ft) between the highway and exit ramp as it approached the SKT end terminal.

Figure 3. Southbound view of the Kia's departure from the travel lane onto the gore area

Figure 4. Southbound view of the Kia's approach to the guardrail impact

Crash

The front plane, right aspect of the Kia struck the impact head of the SKT end terminal with a direction of force in the 12 o'clock sector. Deformation was sustained by the front-right aspect of the Kia, which resulted in the deployment of its supplemental restraint systems. The vehicle maintained its forward momentum, and the associated crash forces began to deform the end terminal and displace the SKT impact head along the W-beam guardrail in a southerly direction. The narrow overlap of the impact head on the right corner of the Kia's front plane deflected the end terminal toward the exit ramp as the vehicle maintained its southerly trajectory. The right front corner area of the Kia and the right front tire/wheel engaged and deformed the first five posts of the end terminal. Associated forces, in conjunction with the cross-slope of the swale between the highway and the exit ramp, redirected the Kia slightly leftward (toward the highway). The vehicle ultimately came to final rest on the rocky surface of a drainage area in the swale facing south, 22.5 m (73.8 ft) south of the initial impact with the SKT end terminal head and 125.0 m (410.1 ft) south of its initial departure from the travel lanes.

Post-Crash

Passersby reported the crash to the local emergency response system, which dispatched law enforcement, fire department, and emergency medical services personnel to the crash site. Prior to their arrival, the Kia's driver and front-row right occupant unbuckled their seat belts and exited the vehicle unassisted. They then focused their attention on the child occupants in the second row.

They removed the second-row occupants from their CRSs and held them in their arms until the emergency responders arrived at the crash site. The front passenger complained of pain and was transported by ambulance to a local hospital for evaluation. The driver and child occupants, although all uninjured, accompanied the front-row right occupant for the convenience of vacating the crash scene. They were not medically treated or transported. The Kia was removed from the crash scene and towed to a local facility.

SKT Guardrail End Terminal

The SKT end terminal, energy-absorbing, was used to terminate the W-beam guardrail system. The SKT installation, 15 m (49.2 ft) long, consisted of an SKT end terminal, two hinged posts at post locations 1 and 2, an anchor cable, and five standard steel posts at post locations 3–7 that supported the W-beam with a composite block-out and carriage bolt. Splices in the W-beam were located at Post 3, Post 5, and Post 7. The SKT installation was manufactured by Road Systems, Inc., of Big Spring, Texas. Manufacturer literature and installation manuals can be found at http://roadsystems.com/skt.html. The FHWA Guardrail Forms documenting the crash and installation are included at the end of this report as Appendix A.

The guardrail and end terminal was a tangent system recently installed adjacent to the shoulder of the new concrete exit ramp. The maximum total height of the W-beam measured 52 cm (20.5 in) at an undamaged section of the beam at Post 9. The Kia struck the face of the end terminal (Figure 5) originally located at Post 1. The impact face measured 51 x 51 cm (20.0 x 20.0 in). The left aspect of the flange of the SKT face was bent inward and deformed 5 cm (2.0 in) at a height of 18 cm (7.1 in) above the bottom aspect, resultant from direct contact by the Kia's right front bumper corner.

Despite the minor damage to the face of the impact head, the feeder channel chute was not deformed, and all welds remained intact. The force of the impact displaced the end terminal to the south and extruded 1.2 m (4.0 ft) of the W-beam. The extruded W-beam curled to the field side, between the exit ramp and the highway (Figure 6).

Figure 5. South-facing view of the struck SKT end terminal and guardrail system

Figure 6. West-facing view of the extruded guardrail and displaced SKT end terminal

Posts of the installation were 10x15 cm (4.0x6.0 in) steel I-beams with black composite block-outs. Average post spacing was 1.9 m (6 ft 4 in) on center. Posts 1 to 5 of the installation were damaged during the crash, along with 9.1 m (30.0 ft) of W-beam guardrail.

Post 1 was the steel foundation post. The base of the post remained intact in the ground, with the slip post and cable attachment separated from the base as a result of the impact by the Kia

(Figure 7). The through bolt remained in place in the base. The post was completely separated from the base and displaced 142 cm (55.9 in) downstream.

Figure 7. Westerly view of the displaced Post 1

Figure 8. Westerly view of the displaced Post 2 at the hinge

Post 2 was a 10x15 cm (4.0x6.0 in) steel hinge post. The base of the post was displaced in the ground as the attachment point between the post and the W-beam separated from slot 2. The hinge point remained intact as the post was displaced to the ground by the impact (Figure 8).

Post 3 was a 10x15 cm (4.0x6.0 in) steel I-beam post. A splice point of W-beam was located at this post location. The composite block-out remained attached to the post by the carriage bolt, the head of which had pulled through the slot in the W-beam. The post was deflected 45 degrees downward (Figure 9) in the south trajectory of the vehicle.

Figure 9. Easterly view of the displacement to Post 3

Figure 10. Easterly view of the bolt separation and displacement of Post 4

Post 4 was rotated approximately 45 degrees. The block-out remained attached to the post via the carriage bolt, and the head of the carriage bolt had pulled through the slot in the W-beam (Figure 10).

Post 5 was at a splice joint of the W-beam. The post was deformed approximately 30 degrees along the vehicle's trajectory and slightly rotated by crash forces (Figure 11). This post was also separated from the W-beam at the attachment bolt location after the head of the carriage bolt had pulled through the slot in the rail. The composite block-out remained attached to the post.

Post 6 remained attached to the W-beam by its carriage bolt, with the block-out in place. The post was deflected approximately 5 degrees to the south by the impact forces (Figure 12).

There was no damage to the guardrail system at Post 7 or beyond (Figure 13). The block-out at Post 7 remained in place, with the carriage bolt attaching the W-beam to the post. A northwest-facing lookback view of the struck guardrail system is depicted in Figure 14.

Figure 11. Easterly view of the bolt separation and displacement of Post 5

Figure 12. Easterly view of the minimal displacement of Post 6

Figure 13. Easterly view of the system at Post 7

Figure 14. Northwesterly lookback view of the damaged guardrail system

2006 Kia Sedona

Description

The 2006 Kia Sedona minivan (Figure 15), manufactured in May 2006, was identified by the VIN KNDMB233666xxxxxx. It was equipped with the LX trim package. At the time of the crash, the vehicle's odometer reading was 387,489 km (240,781 mi). The front-wheel-drive Kia was powered by a transverse-mounted, 3.8 liter, gasoline engine linked to a 5-speed automatic transmission with a forward-console-mounted shift lever. Additional features included power-assisted 4-wheel disc brakes with ABS and electronic brakeforce distribution, hydraulic speed-proportional power-assisted steering, a tire pressure monitoring system, electronic stability control, and traction control. The fuel system consisted of a high-density polyethylene tank mounted to the undercarriage forward of the rear axle with a left-plane-mounted fuel filler port, also located forward of the axle. There was no fuel leakage associated with this crash. The Kia's gross vehicle weight rating was 2,675 kg (5,898 lb), with gross axle weight ratings of 1,360 kg (2,998 lb) front and 1,390 kg (3,064 lb) rear. It was equipped with OEM steel wheels and polymer hubcaps. The Kia was configured with four different tires at the time of the crash; however, they were of the vehicle manufacturer recommended size of P225/70R16. The vehicle manufacturer recommended tire pressure was 240 kPa (35 PSI) at all four axle positions. Specific tire data were as follows:

Figure 15. Right front oblique view of the 2006 Kia Sedona at the time of the SCI inspection

Position	Tire Make/Model	Tire Identification Number	Tread Depth	Restriction	Damage
LF	BF Goodrich Radial Long Trail T/A	OC5L HY11 0303	6 mm (8/32 in)	No	None
LR	Firestone Destination	8XX5 DE5	4 mm (5/32 in)	No	None
RR	Futura Scrambler A/T	U9X5 PAM	2 mm (3/32 in)	No	None
RF	Goodyear Assurance	MDX5 JW1R 0817	3 mm (4/32 in)	Yes	None

The interior of the Kia was configured for the seating of up to seven passengers (2/2/3) with cloth-surfaced, front-row bucket seats, second-row captain's chairs, and a third-row seat with forward-folding split backs. The third-row seatbacks were folded down at the time of the crash. All seat positions were equipped with adjustable head restraints. The front-row and second-row

head restraints were all adjusted to their full-down positions. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seven seat positions. Supplemental restraint systems included front seat belt retractor pretensioners, frontal air bags, front-seat-mounted side impact air bags, and side impact-sensing inflatable curtain (IC) air bags.

Exterior Damage

The Kia sustained damage to the front plane, right aspect from the crash with the end terminal of the guardrail system. Engagement with the impact head and posts of the guardrail system resulted in damage to the grille, right headlight assembly, right-front fender, right wheel, and separation of the right drive axle. The headlights, grille, bumper fascia, and right-front fender were all completely separated from the vehicle. Only the damaged bumper fascia remained with the Kia at the time of the SCI inspection.

Direct contact damage on the exposed bumper beam began 30 cm (11.8 in) right of the vehicle's centerline and extended 37 cm (14.6 in) to the front-right corner (Figure 16). The overall width of the beam was 134 cm (52.8 in). A residual crush profile was documented along the width of the beam using a Nikon total station mapping system, and produced the following measurements: C1 –C3 = 0 cm (0 in), C4 – C5 = 1 cm (0.4 in), and C6 = 4 cm (1.6 in). Maximum crush was located at the right-front bumper corner, and the right wheelbase was reduced 15 cm (5.9 in) by the rearward displacement of the right-front tire/wheel (Figure 17). The collision deformation classification (CDC) assigned to the Kia for the front plane guardrail impact damage was 12FREE4.

Figure 16. Exposed bumper beam of the Kia

Figure 17. Right front view of the damage to the Kia

The barrier algorithm of the WinSMASH model was used to calculate the severity (delta V) of the crash. The calculated barrier equivalent speed of the Kia for the crash event with the guardrail end terminal was 11 km/h (6.8 mph). Based on SCI expertise and the observed vehicle damage, this result appears somewhat underestimated and is presented for informational purposes.

Event Data Recorder

The Kia was equipped with an EDR that was not supported by any tools available to the SCI investigator. Therefore, the investigator could not image any data from the vehicle during the inspection process.

Interior Damage

There was no interior damage or other discernable evidence of occupant contact in the Kia's interior. This likely was due to the use of the manual restraint systems by the front-row occupants, actuation of seat belt pretensioners, deployment of the frontal air bags, and the use of CRS systems in the second row. Additionally, there was no intrusion into the occupant compartment in association with this crash.

Manual Restraint Systems

The Kia was equipped with manual 3-point lap and shoulder seat belts for the seven seat positions. All seat belts consisted of continuous loop webbing and sliding latch plates. The driver's seat belt retracted onto an emergency locking retractor (ELR) while the other systems used switchable ELR/automatic locking retractors (ALR). Both front-row seat belt systems were equipped with retractor pretensioners.

At the time of the SCI inspection, the driver's seat belt was found loosely stowed against the B-pillar. The webbing, which exhibited evidence of significant historical wear, was stained from frequent use. The webbing spooled from and retracted onto the retractor, suggesting that the pretensioner had relaxed after actuation. There was no discernable loading evidence on the webbing or latch plate (Figure 18). However, based on the lack of occupant contact evidence, it was determined that the driver was belted at the time of the crash.

Figure 18. Latch plate of the driver's seat belt system in the Kia

Figure 19. Loading evidence on the latch plate of the Kia's front-row right occupant seat belt system

The retractor of the Kia's front-row right seat belt system was locked in position, presumably as a result of retractor pretensioner actuation. Similar to the driver's system, the front-row right seat belt system displayed significant evidence of historical use. There were 180 cm (70.9 in) of webbing exposed from the locked retractor. Frictional abrasions to the polymer surface of the

latch plate (Figure 19) evidenced occupant loading and supported use of the system by the front-row right occupant at the time of the crash.

The webbing and latch plate of the second-row left seat belt displayed evidence of historical use. Patterned depressions were present on the seat cushion at the second-row left position from the placement and use of the forward-facing CRS. Although the CRS was not in the Kia at the time of the SCI vehicle inspection, it was determined that the second-row left seat belt was used to secure the CRS at the time of the crash. However, there was no discernable loading evidence on the seat belt system to support such use.

The second-row right seat belt was extended from the retractor at the time of the inspection, with the ALR mode of the retractor engaged. There were 157 cm (61.8 in) of webbing extended between the D-ring and the lower anchor. The seat cushion at the second-row right position contained patterned depressions from the forward-facing CRS. Based on the status of the retractor and the extended seat belt webbing, it was determined that the manual seat belt was used to secure the CRS at the time of the crash. There was no discernable loading evidence.

Supplemental Restraint Systems

The Kia was equipped with multiple supplemental restraint systems. This included CAC frontal air bags, front-seat-mounted side impact air bags, and side impact-sensing IC air bags. The frontal air bag system consisted of front seat belt retractor pretensioners and dual-stage air bags for the driver and front-right passenger positions with seat track positioning sensors, seat belt buckle switches, and a front-right occupant presence/classification sensor. Supplemental side impact protection was available with front-seat-mounted and roof side-rail-mounted IC air bags that provided protection for all three rows. In this crash, both front seat belt pretensioners actuated, and the frontal air bags deployed (Figure 20).

Figure 20. Deployed frontal air bags in the Kia

The driver's air bag deployed through an I-configuration module mounted in the four-spoke steering wheel hub. In its deflated state, the driver's frontal air bag was 61 cm (24.0 in) in diameter. It was vented by two ports on the back side of the air bag at the 12 o'clock sector. Internal tethering limited the rearward excursion of the air bag. Scuffs resulting from expansion in the module cover and against the aftermarket steering wheel cover were present on the face

and back side of the air bag. There was no driver-related contact evidence or damage to the driver's frontal air bag.

The passenger's frontal air bag deployed from a top-mounted module in the right instrument panel. A single cover flap was hinged at the forward edge of the module assembly. The deflated air bag measured 44 cm (17.3 in) wide and 56 cm (22.0 in) high. Internal tethers limited the rearward excursion to 46 cm (18.1 in).

Two 4 cm (1.6 in) diameter vent ports were located on the side panels of the passenger's frontal air bag. Deployment related scuff marks were present of the top and right side panel of the air bag from expansion in the module. There also was a scuff on the windshield of the Kia directly forward and above the top instrument panel-mounted module, where the fabric brushed against the glazing surface. There was no evidence of occupant contact to the passenger's frontal air bag or damage resulting from deployment.

Child Restraint Systems

According to law enforcement documentation of the crash, the two second-row child occupants were restrained in the Kia using forward-facing CRSs. Both were removed from the vehicle and unavailable for SCI inspection. Although the Kia was equipped with Lower Anchors and Tethers for CHildren (LATCH) in the seat bight of both second-row captain's chairs, both CRSs were positioned prior to the crash using the vehicle's seat belt systems. Neither child was injured in the crash.

NHTSA Recalls and Investigations

A query of the 2006 Kia Sedona's VIN on www.nhtsa.gov/recalls as of the date of this report identified three open, unrepaired recalls. The first recall, announced on May, 27, 2016, was NHTSA recall no. 16V389 and manufacturer recall no. SC134A. The recall was issued to replace the secondary hood latch, which had the potential to bind and possibly remain open when closed. In affected vehicles, the potential existed for the hood to unexpectedly open while driving. The second recall was also issued on May 27, 2016, with NHTSA recall no. 16V387 and manufacturer recall no. SC133. This recall pertained to a corrosion issue of previously replaced lower control arms, or control arms that had not been replaced that may still be experiencing corrosion issues. The third recall was announced on February 14, 2020, identified by NHTSA recall no. 20V088 and manufacturer recall SC186. This recall involved the possibility for an electrical short in the vehicle's main junction box when the vehicle is parked and the engine is off, which could potentially ignite an engine compartment fire. There were no open recalls concerning this Kia's manual or supplemental restraint systems at the time of this report.

2006 Kia Sedona Occupant Data

Driver Demographics

Age/sex:	53 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Full-rear
Manual restraint usage:	3-point lap and shoulder seat belt system
Usage source:	Vehicle inspection, PCR
Air bags:	Frontal, seat-mounted, and IC air bags available; frontal deployed
Alcohol/drug data:	None, not tested
Egress from vehicle:	Exited vehicle without assistance
Transport from scene:	Not medically transported from scene
Type of medical treatment:	None

Driver Injuries

Injury No.	Injury Description	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
-	None	-	-	-

Source: official records.

Driver Kinematics

The driver of the Kia had the seat track adjusted to a full-rear track position, and the seat back slightly reclined. In this adjusted position, the horizontal distance between the seat back and the mid aspect of the steering wheel-mounted air bag module was 64 cm (25.2 in). The adjustable head restraint was in the full-down position. She was restrained by the manual seat belt system, with the D-ring adjusted to a mid-height position. Although there was no distinct evidence to support her use of the manual restraint system, historical wear indicators on the webbing and the latch plate, in conjunction with the lack of injury and lack of interior occupant contact, indicated seat belt usage by the driver at the time of the crash.

While operating the Kia, the driver steered the vehicle right to avoid a tractor-trailer that encroached into her lane of travel. The Kia entered the gore between the exit ramp and the travel lanes while it maintained a tracking trajectory. At impact with the guardrail end terminal, the Kia's front seat belt pretensioners actuated, and the frontal air bag system deployed. The driver responded to the 12 o'clock frontal crash forces by translating forward, which caused her body to load the manual seat belt system and the deployed driver's frontal air bag. The combination of safety systems prevented her from direct contact with interior components and mitigated injury. The driver denied injury at the crash site, and, although she was not medically treated or transported, she accompanied the front passenger in the ambulance from the crash scene.

Front-Row Right Occupant Demographics

Age/sex:	46 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Full-rear
Manual restraint usage:	3-point lap and shoulder seat belt system
Usage source:	Vehicle inspection, PCR
Air bags:	Frontal, seat-mounted, and IC air bags available; frontal deployed
Alcohol/drug data:	None
Egress from vehicle:	Exited vehicle without assistance
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Treated and released in hours of the crash

Front-Row Right Occupant Injuries

Injury No.	Injury Description	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Unknown	N/A	N/A	N/A

Source: records requests denied.

Front-Row Right Occupant Kinematics

The front-row right occupant of the Kia was seated with the seat track adjusted full-rear, the seat back in a slight recline, and the adjustable head restraint full-down. In this adjusted position, the horizontal distance between the seat back and the instrument panel was 94 cm (37.0 in). The occupant used the manual seat belt system, with the D-ring adjusted to the full-up position. Her use of the seat belt system was determined from frictional abrasions on the latch plate and the length of exposed webbing as observed by the SCI investigator during the vehicle inspection.

According to law enforcement documentation of the crash, the front-row right occupant was asleep in the front-row right position when the crash occurred. At impact with the guardrail end terminal, she initiated a forward trajectory in response to the 12 o'clock direction of force. She loaded the 3-point lap and shoulder seat belt system, evidenced by the frictional abrasions on the latch plate documented during the SCI vehicle inspection. The occupant also contacted and loaded the deployed frontal air bag, although there was no supporting contact evidence on the air bag.

The front-row right occupant complained of possible injury at the crash site. She was evaluated by EMS and transported by ambulance to a local hospital, where she was evaluated, treated, and released within hours of the crash. Requests for records documenting the occupant's course of treatment were denied by the treating facility, which refused to release records without her express written authorization.

Second-Row Left Occupant Kinematics

Age/sex:	3 years/male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Forward-facing captain's chair with adjustable head restraint
Seat track position:	Fixed
Manual restraint usage:	Forward-facing CRS secured using vehicle's 3-point lap and shoulder seat belt system
Usage source:	Vehicle inspection, PCR
Air bags:	IC air bags available, not deployed
Alcohol/drug data:	None
Egress from vehicle:	Removed from CRS by front-row occupants
Transport from scene:	Not medically transported
Type of medical treatment:	None

Second-Row Left Occupant Injuries

Injury No.	Injury Description	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
-	None	-	-	-

Source: official records.

Second-Row Left Occupant Kinematics

The 3-year-old male second-row left occupant of the Kia was seated in a forward-facing CRS and restrained by the integral harness system. The CRS was secured to the Kia by the vehicle's 3-point lap and shoulder manual restraint system. The CRS was removed from the vehicle and unavailable for SCI inspection.

At impact with the guardrail end terminal, the child initiated a forward trajectory in response to the 12 o'clock crash forces. He loaded the integral harness system of the CRS, which distributed the associated forces over his torso and pelvic regions and prevented him from contact with interior components. The CRS remained secured in position by the 3-point lap and shoulder belt system. As a result of his restraint in the CRS, the child occupant did not sustain injury. Although the child was not medically treated or transported, he accompanied the front passenger in the ambulance from the crash scene.

Second-Row Right Occupant Demographics

Age/sex:	3 years/male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Forward-facing captain's chair with adjustable head restraint
Seat track position:	Fixed
Manual restraint usage:	Forward-facing CRS secured using vehicle's 3-point lap and shoulder seat belt system
Usage source:	Vehicle inspection, PCR
Air bags:	IC air bags available, not deployed
Alcohol/drug data:	None
Egress from vehicle:	Removed from CRS by front-row occupants
Transport from scene:	Not medically transported
Type of medical treatment:	None

Second-Row Right Occupant Injuries

Injury No.	Injury Description	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
-	None	-	-	-

Source: official records.

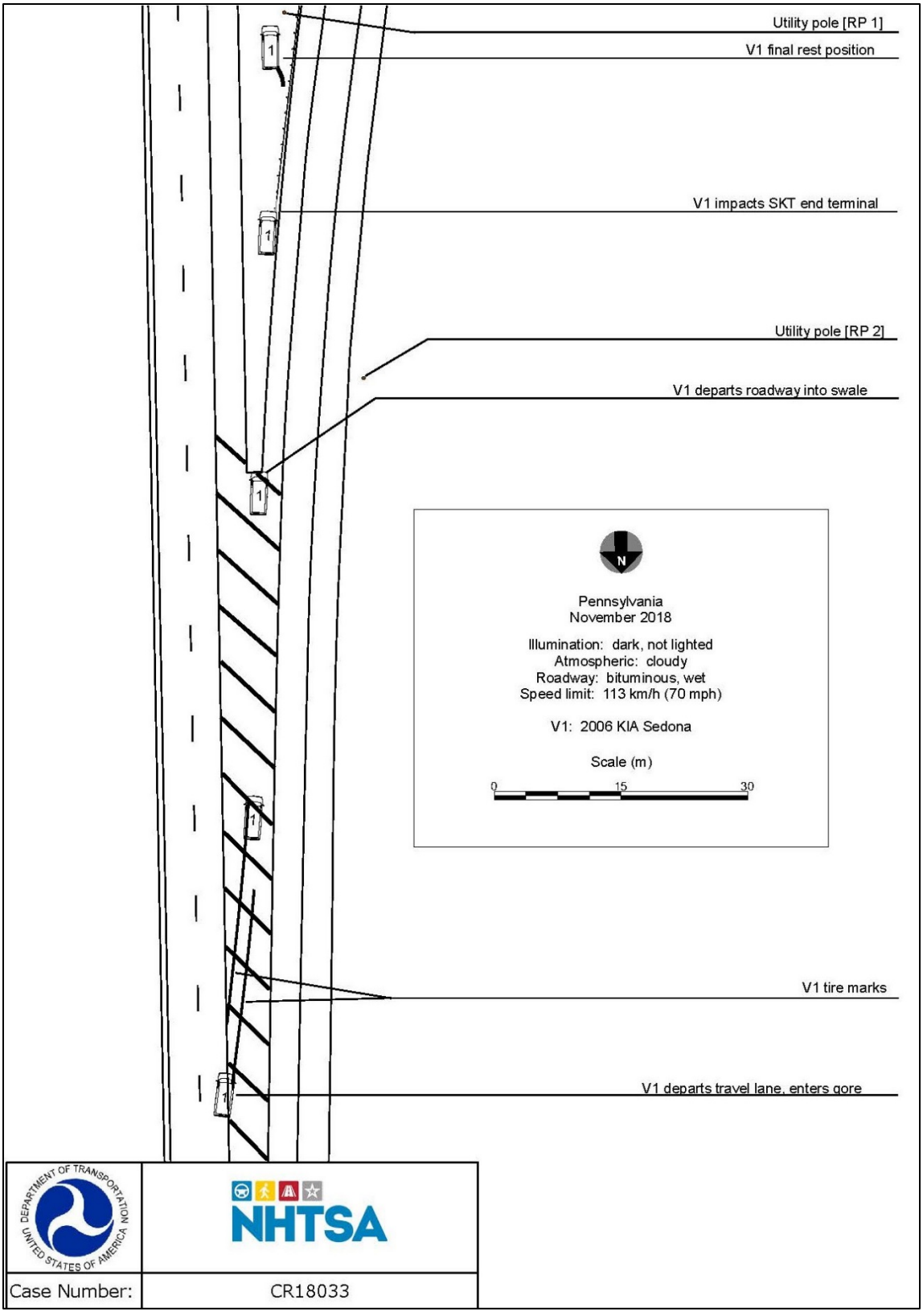
Second-Row Right Occupant Kinematics

The 3-year-old male second-row right occupant was seated in a forward-facing CRS and restrained by its integral harness system. The CRS itself was secured in the Kia by the vehicle's 3-point lap and shoulder seat belt system, with the retractor's ALR mode engaged.

At the time of the SCI vehicle inspection, the CRS was removed from the vehicle and unavailable for inspection. There were 157 cm (61.8 in) of exposed webbing extended from the ALR retractor at the time of the SCI inspection. Depressions were visible in the vehicle's seat cushion, consistent with the base of the CRS.

At impact with the guardrail end terminal, the child initiated a forward trajectory. His body loaded the integral harness system of the CRS, which distributed the associated forces over his torso and pelvic regions and prevented him from contact with interior components. The CRS remained secured in position by the 3-point lap and shoulder belt system. As a result of his restraint in the CRS, the child occupant did not sustain injury. Although the child was not medically treated or transported, he accompanied the front passenger in the ambulance from the crash scene.

Crash Diagram



Appendix A: Federal Highway Administration Guardrail Forms

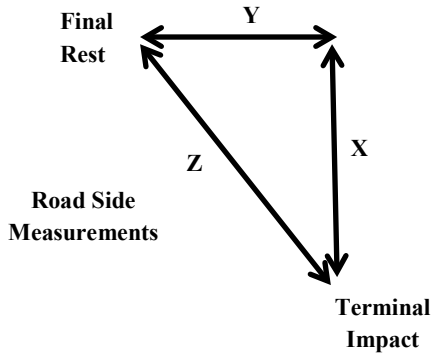
Case No.: CR18033

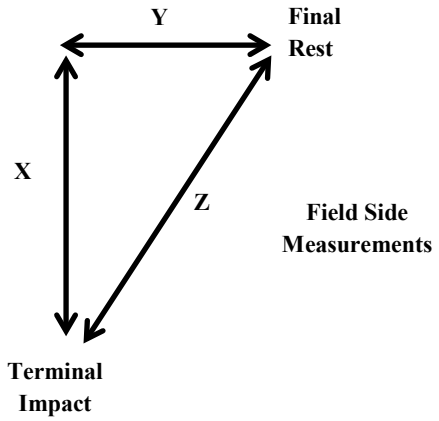
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	Nov 2018	**Time of Crash**	Nighttime
Case Number	CR18033	**State**	PA
Traffic Route	Limited Access	**Direction (Southbound = SB)**	SB
Ambient Conditions (at time of crash)			
Temperature (°F)	46 °F	**Lighting**	Dark, not lighted
Atmospheric	Cloudy		

SCENE INFORMATION	
Type of area where crash occurred	☐Urban ☒Rural ☐Suburban
Terminal on a horizontal curve?	☒No ☐Curve/LT ☐Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	30 mph
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 63.6 ft ☐Road side ☒Field Side
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 62.9 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 9.5 ft
Super elevation	☐+2% ☐-2% ☒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: CR18033

ON-SCENE INFORMATION		
End Treatment Type	☒Extruder	☐ET2000 ☐ET-PLUS 4in ☐ET-PLUS 5in ☒SKT ☐FLEAT ☐SOFT STOP
	☐Telescope	☐X-LITE ☐X-TENSION
Curb?	☒No ☐Yes	☐AASHTO Type A ☐AASHTO Type B ☐AASHTO Type C ☐AASHTO Type D ☐AASHTO Type E ☐AASHTO Type F ☐AASHTO Type G ☐AASHTO Type H
Curb Height: N/A		

GUARDRAIL INSTALLATION

Post No.	Post		Block-Out		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type	Dim.	Type	Dim.					
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)	Yes No Unknown	Describe	Travel Way	Curb	
1	STEEL BOX	6 in x 6 in	NONE	N/A	NO	NONE	23 in	N/A	6 ft 5 in
2	STEEL I-BEAM	6 in x 4 in	NONE	N/A	NO	NONE	18.5 in	N/A	6 ft 10 in
3	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	22.0 in	N/A	6 ft 4 in

Case No.: CR18033

GUARDRAIL INSTALLATION									
Post No.	Post		Block-Out		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type Steel Wood Other	Dim. D x W (in.) or Dia. (in.)	Type Steel Wood Composite	Dim. D x W (in.)	Yes No Unknown	Describe	Travel Way	Curb	
4	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	21 in	N/A	6 ft 4 in
5	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	19.5 in	N/A	6 ft 4 in
6	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	17.5 in	N/A	6 ft 4 in
7	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	15.0 in	N/A	6 ft 3 in
8	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	13.5 in	N/A	6 ft 0 in

Additional Comments:

No damage to guardrail system at Post 7 or beyond.

Case No.: CR18033

EXTRUDER			
Feeder Channel Width at impact head	☐4inches ☐5 inches ☒Other 4.7 in		
Guide Chute Exit Height (in.)	13.0 – 20.5 in		
Connection of feeder channels to head damaged?	☒No ☐Yes	Are Welds Broken?	☒No ☐Yes
Anchor Cable Present?	☐No ☒Yes	Connected?	☐No ☒Yes
Rail Extrusion?	☐No ☒Yes	Length (ft. in.)	4 ft 0 in
Rail Extrusion Direction	☐Traffic Side ☒Field Side ☐N/A		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	38.4 ft		

TELESCOPE				
Rail Displacement	❒No	❒Yes Length:	No of Panels Displaced	❒1 ❒2 ❒3 ❒4 ❒5 ❒6

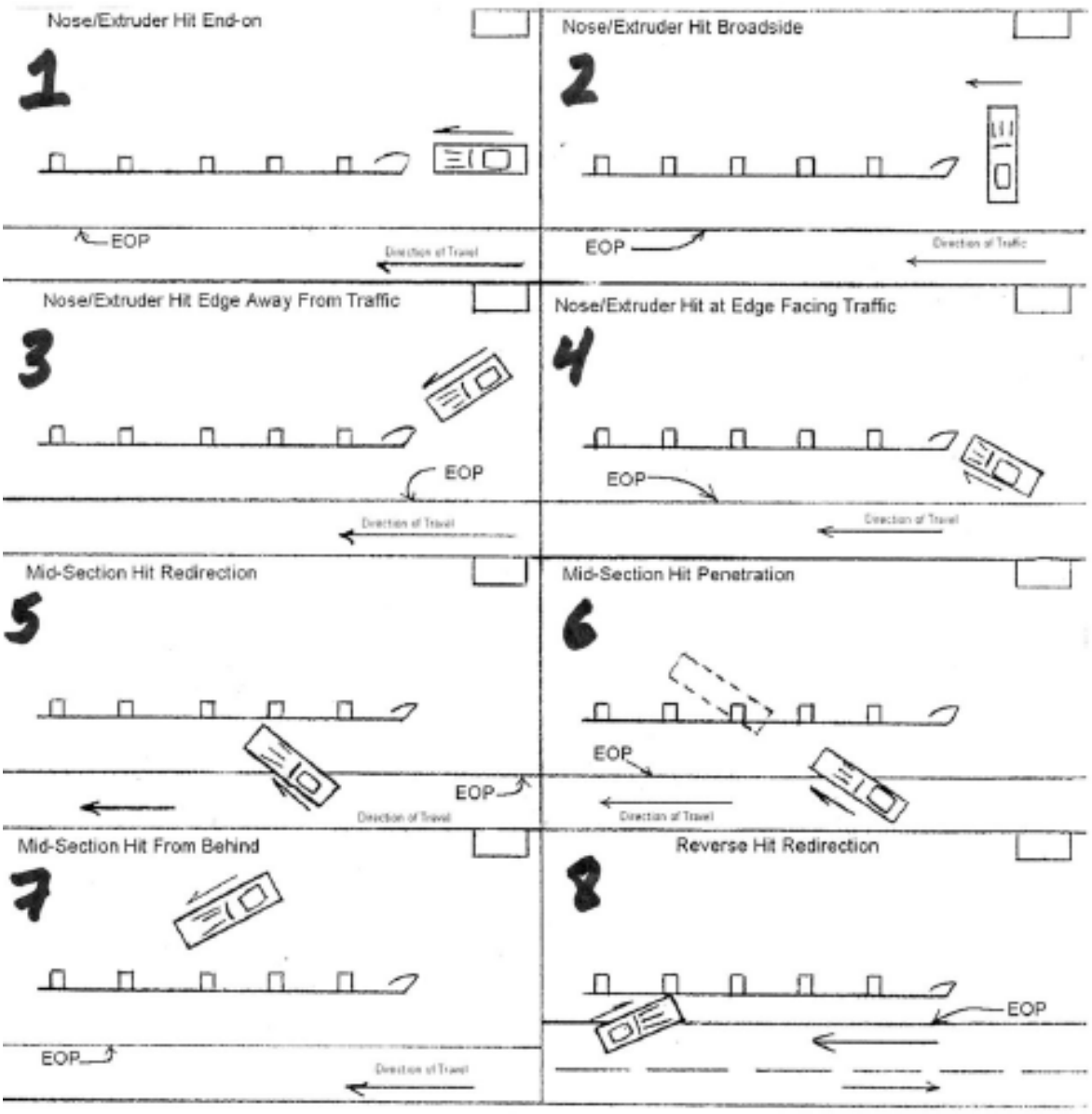
ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	☒No	☐Yes	No. of Kinks in Rail: N/A
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	☒No ☐Yes		
Did vehicle impact other objects after impact with terminal?	☒No ☐Yes		
Object(s) Contacted	N/A		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in Advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	0%	0%	-5%
Adjacent Lane Width (ft)	13.4 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Concrete		
Shoulder Type	Concrete		
Shoulder Width (ft)	8.6 ft		
Guardrail Height (in)	29 in (measured between Posts 8 & 9)		

Case No.: CR18033

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	2006 Kia Sedona	
Vehicle Identification Number (VIN)	KNDMB233666xxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	4,645 lb	
Vehicle orientation upon impact	☒Case Type 1 ☐ Case Type 2 ☐ Case Type 3 ☐ Case Type 4 ☐ Case Type 5 ☐ Case Type 6 ☐ Case Type 7 ☐ Case Type 8 ☐ Other	
If 'Other', describe	N/A	
Collision Deformation Classification	12FREE4	
Delta-V	6.2 - 15.5 mph	
Occupant Compartment Penetration of rail	☒No	☐Yes; Describe: N/A
Did the Vehicle Rollover?	☒No ☐Yes	
Quarter Turns (NASS EDS variable: Rollover)	☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 ☐11 ☐12 ☐13 ☐14 ☐15 ☐16 ☐17+	
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	N/A	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	N/A	

Case No.: CR18033



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**National Highway
Traffic Safety
Administration**

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